សង្ខិត្តន័យ—Abstract

អត្ថបទទី៥៖ ចំណេះដឹង និងការយល់ឃើញរបស់គ្រូបង្រៀនក្នុងការអនុវត្តបំណិនត្រិះរិះពិចារណា លើការបង្រៀនមុខវិជ្ជាគីមីវិទ្យា៖ ករណីសិក្សានៅសាលាមធ្យមសិក្សាទុតិយភូមិក្នុងខេត្តកំពង់ឆ្នាំង ប្រទេសកម្ពុជា

សង្ខិត្តន័យ

ការសិក្សានេះផ្តោតសំខាន់ទៅលើការកំណត់នូវកម្រិតចំណេះដឹងរបស់គ្រូបង្រៀនមុខវិជ្ជាគីមីវិទ្យា និងរបៀបនៃការយល់ឃើញរបស់ពួកគាត់ពាក់ព័ន្ធនឹងការបង្រៀនបំណិនត្រិះរិះពិចារណា។ ការសិក្សានេះបានប្រើប្រាស់វិធីសាស្ត្រស្រាវជ្រាវបែបចម្រុះ (Explanatory sequential mixed-method design) ដែលមានការចូលរួមពីគ្រូបង្រៀនចំនួន ៥០នាក់ មកពីវិទ្យាល័យចំនួន ១៦ នៅក្នុងខេត្តកំពង់ឆ្នាំង។ ស្ថិតិបែបពណ៌នាត្រូវបានប្រើក្នុងការវិភាគទិន្នន័យបែបបរិមាណវិស័យ ខណៈពេលដែលការកូដ ការវិភាគរកចំនួន និងខ្លឹមសារសំខាន់ៗ (content and thematic analysis) ត្រូវបានគេប្រើសម្រាប់ការវិភាគទិន្នន័យបែបគុណវិស័យ។ លទ្ធផលស្រាវជ្រាវបានបង្ហាញថា សៀវភៅសិក្សាគោលគីមីវិទ្យានៅមធ្យមសិក្សាទុតិយភូមិបានផ្តល់នូវបំណិនត្រិះរិះពិចារណាក្នុងកម្រិតទាប ដែលសៀវភៅទាំងនោះបានផ្តល់នូវកស្តុតាងតិចតួចដើម្បីជួយសិស្សអោយឈានដល់កម្រិតវិភាគ ដែលបានបង្ហាញនៅក្នុងទ្រឹស្តីប្លូមតាក់សូណូមី (Bloom's taxonomy)។ លើសពីនេះទៅទៀត ទោះបីជាលោកគ្រូ អ្នកគ្រូទាំងអស់មានចំណេះដឹងលើបំណិនត្រិះរិះពិចារណាច្បាស់លាស់ក៏ដោយ ពួកគាត់ទំនងជាមានការយល់ដឹងមិនច្បាស់លាស់ចំពោះចំនុចមួយចំនួនដែលទាក់ទងនឹងចំណេះដឹងនៃបំណិនត្រិះរិះពិចារណា។ បន្ថែមពីនេះទៀត គ្រូបង្រៀនភាគច្រើនមានយោបល់វិជ្ជមាន និងការយល់ស្របខ្លាំងទៅលើការបង្រៀនបំណិនត្រិះរិះពិចារណា ប៉ុន្តែការអនុវត្តនៃការផ្ទេរបំណិនត្រិះរិះពិចារណាទៅកាន់សិស្សនៅមានកម្រិតនៅឡើយ ដែលបញ្ហានេះកើតមានឡើងដោយសារតែកត្តាសំខាន់ៗមួយចំនួន។ ហេតុដូចនេះ ការសិក្សាបន្តទៀតចាំបាច់ត្រូវផ្តោតទៅលើការស្វែងរកកត្តាដែលជះឥទ្ធិពលទៅលើចំណេះដឹង និងការយល់ឃើញលើការបង្រៀនបំណិនត្រិះរិះពិចារណារបស់គ្រូ។

ពាក្យគន្លឹះ៖ បំណិនត្រិះរិះពិចារណា ការយល់ឃើញ ចំណេះដឹង គ្រូបង្រៀនមធ្យមសិក្សាទុតិយភូមិ សៀវភៅសិក្សាគោលគីមីវិទ្យា

Teachers' Knowledge and Perception in Implementing Critical Thinking Skills Practice in Chemistry: A Case of Upper Secondary Schools in Kampong Chhnang Province, Cambodia

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Abstract

The general focus of this study is to identify the level of chemistry teachers' knowledge and how they perceive the prospect of teaching critical thinking skills (CTS). The study used an explanatory sequential mixed-method design involving 50 teachers from 16 upper secondary schools in Kampong Chhnang province. Descriptive statistics were used for quantitative analysis, while coding, content and thematic analysis were employed for qualitative analysis. The results revealed that upper secondary chemistry textbooks have a low level of CTS; they offer only a minor reference to help students reach the level of analysis present in the cognitive domain of Bloom's taxonomy. Moreover, although these teachers had an accurate level of knowledge of CTS, they seemed to have an uncertain understanding of a few items related to CTS knowledge. In addition, most of the teachers had positive opinions and strong agreement on the perception of CTS teaching, but they had a limited or moderate level of transferring CTS to their students due to some crucial factors. Further studies need to focus on investigating the factors that influence teachers' knowledge and perception of teaching CTS.

Keywords: Critical thinking skills; Perception; Knowledge, Upper secondary school teachers; Chemistry textbooks

1. Introduction

Generally, having the ability to think critically is viewed as a necessary skill for people in society. This is especially true in the case of the fast and dynamic socio-economic development that would necessitate the young adult population to compete in a diverse job market. In addition, as information and communication technology in the 21st century is constantly evolving, the work done by people and the work done by machines tend to be in opposition. The future work will possibly be automated by artificial intelligence and robotics (Dede, 2009; Vincent-Lancrin et al., 2019). Taking the case of changes in the field of education as an example, with the help of diverse sources of information and advanced social media platforms, students can get information as well as learning materials and content related to any subjects easily through their smartphones or personal computers. As a result, it now seems less interesting to attend an actual physical class. These changes have profound implications for

teachers' competency development and emphasize the necessity for teachers to equip themselves with new skills to effectively teach students the much-needed 21st-century skills such as critical thinking, problem-solving, decision making, collaboration, creativity, and communication skills (Assessment and Teaching 21st Century Skills, 2012; Klassen & Tze, 2014; Schleicher, 2012).

Critical thinking (CT) is one of the most significant skills that students must acquire to solve problems and make correct judgments on a variety of aspects arising in this rapidly changing world (AAC&U, 2011; Butler, 2012). According to a series of studies conducted by researchers at Stanford University, countries that excelled on the Programme for International Student Assessment (PISA), a test used to measure 21st-century skills, particularly critical-thinking and problem-solving skills, had a higher increase in GDP growth than the countries that did not perform well in PISA (Partnership for 21st Century Skills, 2008). However, critical thinking skills (CTS) cannot be easily acquired only through technology; it requires more extensive guidance and instruction, through practical activities, from instructors or teachers in an actual class. Moreover, CTS has become an essential skill for meeting the needs of employers who are seeking solutions to the problems arising within a competitive global business market (Alazzi, 2008; Bataineh & Alazzi, 2009; Butler, 2012). In line with that change, the Cambodian Ministry of Education, Youth and Sport (MoEYS) has extensively worked on formulating a curriculum framework reform for general and technical education in which the development of self-study, research, critical thinking, communication, and problem-solving skills is the primary purpose for all learners (MoEYS, 2015).

However, the statistics of the Grade 12 National Exit Examination in 2015 show that the level of the cognitive domain of the different test items was relatively low; that is, the items were only at the levels of remembering and understanding (Chey & Khieu, 2017), and this did not satisfy the three upper levels (i.e., analyzing, evaluating, and creating) of Bloom's taxonomy of educational objectives, which are often considered as a definition of CT (Ennis, 1993). Against this background, this study aims to examine the knowledge and perception of CTS of upper secondary school chemistry teachers in Kampong Chhnang province, Cambodia. In order to achieve this objective, the study attempts to answer three research questions as follows:

1. *To what extent is critical thinking skills included in the upper secondary school chemistry textbooks?*
2. *What is the extent of upper secondary school chemistry teachers' knowledge of critical thinking skills?*
3. *How do upper secondary school chemistry teachers perceive teaching critical thinking skills?*

2. Review of literature

2.1 Defining critical thinking

There is an increase in the number of studies examining the meaning of the term *critical thinking skills*. Historically, the concept of CT was originated by the American philosopher, John Dewey, who called it "reflective thinking" (Dewey, 1910, p. 6). Eventually, the meaning

of CT evolved with variations in its definition from one researcher to another in their respective field of study. However, the most common definition was developed by Robert Ennis (1985, p. 46), who defined CT as "reasonable reflective thinking that focuses on deciding what to believe or do." Several other studies conceptualized CT as a process in which high-level cognitive skills of analysis, synthesis, and evaluation are supposed to be used to assess truth or mistake associated with a situation (Celikkaya, 2012 as cited in Aybek & Aslan, 2016). Given that the objective of the study is to examine teachers' knowledge and perception of implementing CTS in teaching chemistry, the researcher believes that the definition of CT provided by Celikkaya (2012) is more appropriate for this study.

2.2 The role of critical thinking skills

Considering the discussion on the importance of CTS, several questions arise: "Why do students need to learn CTS?"; "Are there any applicable strategies to teach learners CTS?"; and/or "How do teachers help students in learning CTS?" These questions promote eagerness among researchers to find answers and justify them. Basically, learners need to be armed with 21st- century skills to be able to function as global citizens, operate effectively in schools, and compete in the global economy (Carlgren, 2013). CTS is one of the skills in the 21st-century which learners must acquire in order to define and solve problems, devise strategies, shift focus, and consider alternatives (Lee, 2005). CTS is viewed as a tool that helps develop a high academic setting in which students need to reach their goals established by academic sources or teachers (Ennis, 1962).

Additionally, acquiring CTS can lead to mental independence and help in accomplishing greater productive tasks with others. It also helps in revealing the working of people's minds and sharing ideas with others, recognizing and directing the inner processes related to understanding issues, communicating ideas and beliefs, and analyzing and making decisions to solve a problem (Mayfield, 2007). Studying CTS benefits the learners not only in the context of the classroom and workplace but also daily life (Bassham et al., 2005). For instance, in classrooms, students can learn a variety of skills related to CT such that they can better understand the arguments and beliefs of others and help critically evaluate those arguments and beliefs and develop well-supported arguments to defend their own opinions and beliefs. Furthermore, in workplaces, using CTS, individuals can solve problems effectively, think creatively, gather and analyze information thoughtfully, draw appropriate conclusions, communicate clearly and efficiently, and avoid making biased decisions. Duron et al. (2006) also supported the idea that CT is required in the workplace, as it can help people to deal with mental and spiritual questions and evaluate people, policies, and institutions, thereby avoiding social problems. In daily life, CT can help people make decisions more carefully, clearly, and logically. It can also free them from unexamined assumptions and bias and help promote democracy in society (Bassham et al., 2005).

2.3 Studies on teachers' perceptions of critical thinking skills

Regarding how CT is perceived, Kenney (2013) claimed that CT is not an inherent skill, rather it is a skill that can be learned and enhanced with educational progress, from school to college

and then to university. However, a qualitative study on the perceptions of CT among social studies teachers at a Jordanian secondary school revealed that teachers have little familiarity with the meaning of and the teaching strategies for CTS (Alazzi, 2008). The result of the study also showed that according to the Ministry of Education of Jordan, Jordanian secondary school teachers need to teach CT only to a small extent.

Similarly, a study on the attitudes toward CTS among 72 high school teachers of a Hong Kong secondary school in China indicated that they had a narrow conception of the meaning of CTS (Stapleton, 2011). The teachers expressed strong support for the inclusion of CTS in the curriculum and the desire to be trained on how to teach it and to provide a more vivid definition of CT in educational documents. Another study using a semi-structured questionnaire conducted by Choy and Cheah (2009) on teacher perceptions of CTS among students and their influence on higher education in Malaysia revealed that teachers were aware that they taught CTS to their students and expected that CTS would provide the intellectual stimuli needed to develop students' critical thinking ability. Yet, the participants of this study did not understand the requirements for cultivating CT among students, and they concentrated more on ensuring subject matter comprehension.

A study conducted by Bezanilla et al. (2019) attempted to identify what teachers understand by CT and how they apply it in their teaching by examining 230 university teachers from Spain and Latin America. The study results indicated that the teachers believed that oral and written reflection and argumentation, reading, analysis, synthesis of resources, and case studies were the most effective ways to teach and develop CT. Moreover, Gashan (2015) conducted a quantitative study with 29 male pre-service teachers involved in a teacher education program in Saudi Arabia to explore their knowledge and perceptions of CTS. The results demonstrated that pre-service teachers were optimistic about the importance of teaching CTS, but they had underdeveloped knowledge of CTS and wondered whether they have the skills necessary to promote CTS among students within the classroom setting. The study suggested a need for further investigation on exploring CTS knowledge among college teachers in order to better understand the extent to which college teachers are prepared to teach CTS. The present study responds to this call, by examining Cambodian upper secondary school chemistry teachers' knowledge and perception of CTS.

3. Methodology

This study employed an explanatory sequential mixed-methods design, involving a quantitative data collection and analysis conducted in the first phase, followed up by a qualitative data collection and analysis in the second phase. This method provides a more insightful understanding of the problem due to the integration or mixing of the quantitative and qualitative data (Creswell & Creswell, 2018). According to Creswell (2014), using only one type of data collection has strengths and weaknesses; however, blending or mixing data can provide a stronger view by addressing the weaknesses of each type of data to develop a more comprehensive understanding of a research question or a problem. Basically, the quantitative results determined the types of respondents to be purposefully selected and the types of

questions that the respondents will be asked in the qualitative phase. In the second phase, the qualitative data was collected using a semi-structured interview guide and classroom observation scoring sheet. The participants were asked to give consent to being audiotaped and videotaped during the interview and classroom observation, respectively. In this study, the quantitative statistical results are presented first, followed by a discussion of the qualitative findings. Finally, an interpretation of the results from both types of data was made by using qualitative data to explain the quantitative data.

3.1 Participants

A total of 50 respondents (32 males and 18 females) from 16 upper secondary schools in Kampong Chhnang province participated in the survey. Among the 50 respondents, 8 respondents (one from each district in the province) were purposively selected for interviews and four out of eight respondents were purposively selected for classroom observation based on their perception, teaching experience, and major.

3.2 Questionnaires

The sources of information for data collection that have been included in this study are public chemistry textbooks. These textbooks were published by MoEYS for the upper secondary level. The first textbook (grade 10) was published in 2007, the second textbook (grade 11) in 2008, and the third textbook (grade 12) in 2009. These textbooks are the essential sources that all the teachers across the country rely on for teaching chemistry. Therefore, they have been considered as the vital sources for data collection and analysis in this study. The purpose of using these textbooks is to analyze the extent to which CTS has been included in the textbooks of grades 10–12. The researcher used the questions in each chapter as a unit of analysis and compared it with the checklist of the verb forms using the Revised Bloom's taxonomy (2001). A self-reported survey questionnaire developed by Gashan (2015) was adapted for this study. This questionnaire was used because the digested components of the survey questionnaire are strongly related to the concept and objective of this study, where knowledge and perception are considered to be important variables. Another important justification for the adaptation of this questionnaire is that it was mainly developed for evaluating teachers' knowledge and perception of CTS, which is in line with the objective of this study. To evaluate teachers' knowledge, codes such as 0 for inaccurate (0 = inaccurate), and 1 for accurate (1 = accurate) were used. Moreover, a five-point Likert-type scale (ranging from 1 = strongly disagree to 5 = strongly agree) was used to measure teachers' perception of implementing CTS. Furthermore, the internal consistency of the questionnaire (Cronbach's alpha = 0.93) is highly reliable and thus is appropriate for this study. Specifically, this questionnaire was employed as an example in measuring the teachers' knowledge of CTS, as seen below.

Skill	**Yes**	**No**
1. Examining relationships among statements.		
2. Interpreting the meanings from variety of data or experiences.		
3. Assessing the quality of ideas or data.		
4. Identifying alternative claims and drawing conclusion.		

Regarding teachers' perception, the following statement was used as an example which ranged from 1 to 5 (1= Strongly Disagree, 5= Strongly Agree).

Statement	SD	D	N	A	SA
1. Critical thinking engages students' higher order thinking (analyzing, evaluating, and creating).	1	2	3	4	5
2. Critical thinking encourages students to become independent thinkers.	1	2	3	4	5
3. Critical thinking encourages students to become active learners.	1	2	3	4	5
4. Critical thinking can be used to achieve better learning outcomes.	1	2	3	4	5

3.3 Interviews

To gain more insights into the result of the quantitative analysis, a semi-structured interview guide was adopted from Alazzi (2008) and modified by the researcher to garner a comprehensive understanding of the survey questionnaire results. The interview protocol for determining teacher perceptions consisted of eight items, followed by sub-questions for each one. The questions focused mainly on the four critical viewpoints regarding the importance of CTS (2 items), the support they have received from the various stakeholders (3 items), the difficulties they have encountered while teaching a lesson in the classroom (2 items), and their CTS teaching practice (1 item). The interviewed participants were chosen based on their demographic information (age, teaching experience, gender, and major) and their perception from the quantitative result (i.e., strong perception). Due to time constraints, the researcher did not interview the respondents who had a weak perception

3.4 Classroom observations

Additionally, the researcher observed the teaching practice of the four selected respondents based on their level of perception (strong perception), experience, and major (chemistry and others). The purpose of classroom observations was to see how the participants implemented their knowledge and perception of CTS in their teaching practice. This method was used to triangulate the results of the survey questionnaire and the interview. A classroom observation scoring sheet was developed by the researcher following guidelines from Stevens and Levi (2013) who provided the rubrics to evaluate the CTS teaching. From the scoring sheet, four main themes were identified, namely communication with students, questions to students, discussion guidance to students, and teaching materials for students' understanding of the subject. There were three questions that corresponded to the meaning of each main theme. The researcher rated the classroom observation on a scale of 1–5 (1 = not at all, 2 = poor, 3 = moderate, 4 = good, and 5 = very good). In addition, for more qualitative evidence, a classroom observation timeline was created following Stigler and Hiebert's (1999) suggestions to explain how the four teachers used their lesson time.

3.5 Data analysis and interpretation

The quantitative data from the survey was entered into a Microsoft Excel spreadsheet and later imported into the Statistical Package for Social Science (SPSS) version 23.0 for analysis. The demographic characteristics of the participants were analyzed using descriptive statistics. Each demographic characteristic was computed to determine the frequency and percentage. Descriptive statistics were also used to evaluate the teachers' knowledge of CTS by calculating frequencies, percentages of the respondents who got the answers, mean score, and standard deviation for the three sections of knowledge of CTS. These descriptive statistics were also used to compute teachers' perception of CTS, scaling from strongly disagree to strongly agree. This calculation was used to check to what extent was each item in the questionnaire rated by the respondents. The same calculations of the descriptive statistics were also done for the textbook analysis. Additionally, another rater in the field of chemistry helped rate the verbs from the questions in each textbook in comparison with the verbs from the Revised Bloom's taxonomy (2001). Then, the interrater reliability was measured using SPSS to check the level of agreement between the researcher and another rater using Cohen's Kappa value. This process helped the researcher to ensure the data reliability from different raters (McHugh, 2012).

4. Results and discussion

4.1 The extent to which critical thinking skills were included in upper secondary school chemistry textbooks

As shown in Table 1 below, only a small proportion of the questions in each chemistry textbook reached the level of analyzing (level 4). However, the upper two levels (evaluating and creating) could not be found in any of the questions in each textbook. It was found that only 59 questions (7.9%) out of a total of 749 questions in the three upper secondary chemistry textbooks required a higher level of CTS. However, 690 questions (92.1%) only demanded a lower level of CTS. This result was consistent with Lau et al.'s (2018) study which indicated that most of the textbooks among the 100 textbooks used in their study were not appropriately designed to stimulate advanced cognitive processes, such as evaluating and creating, but for basic and intermediate learning that is based on the revised Bloom's taxonomy.

Furthermore, the result of this study slightly corroborated the findings of Upahi and Jimoh (2015) who had conducted a similar study on the classification of end-of-chapter questions in the senior school chemistry textbooks used in Nigeria. Upahi and Jimoh found that 24% of the end-of-chapter chemistry questions required higher-order cognitive skills, while the percentage of questions at the understanding level was the highest at 41% among the remaining 76%. The percentage of questions in the categories of evaluating and creating were found to be low. In contrast, the results of the current study showed that there was no questions that fell into the categories of evaluating and creating.

In the current study, the percentage distribution of the questions found across the chemistry textbooks indicated that 7.9 % of the total questions required in the *analyzing* category. This result is different from the finding of Thote and Gowri (2020), who found a higher proportion

(30%) of the questions falling in the analyzing category. Thus, the upper secondary chemistry textbooks provided by MoEYS tended to require low levels of CTS.

Table 1
Results of Chemistry Textbook Analysis

Grade	Number of Questions	L1		L2		L3		L4		L5		L6	
		Qs	%	Qs	%	Qs	%	Qs	%	Qs	%	Qs	%
10	143	78	54.5	21	14.7	33	23.1	11	7.7	0	0.0	0	0.0
11	295	110	37.3	81	27.5	83	28.1	21	7.1	0	0.0	0	0.0
12	311	107	34.4	121	38.9	56	18	27	8.7	0	0.0	0	0.0
Total	**749**	**295**		**223**		**172**		**59**		**0**		**0**	

Note: **(L1:** Remembering, **L2:** Understanding, **L3:** Applying, **L4:** Analyzing, **L5:** Evaluating, **L6:** Creating**)**

4.2 The extent to which chemistry teachers possess the knowledge of critical thinking skills

The second question intended to identify the level of CTS knowledge of the chemistry teachers. The question was answered through a review of individual responses to the second part of the questionnaire which had three sections—skills, concepts, and nature. The first section of this part examined the upper secondary school chemistry teachers' knowledge regarding the skills and sub-skills of CT.

Table 2
Sum, Mean and Standard Deviation (SD) for Skills of CT

Skill	Sum	M	SD
1. Examining relationships among statements.	36	.72	.45
2. Interpreting the meanings from a variety of data or experiences.	46	.92	.27
3. Assessing the quality of ideas or data.	45	.90	.30
4. Identifying alternative claims and drawing conclusion.	48	.96	.20
5. Presenting results of one's reasoning.	39	.78	.42
6. Generating original and new insights.	42	.84	.37
7. Delivering information that committed to memory.	17	.34	.48
8. Generating questions from a particular topic.	46	.92	.27
9. Confirming, validating, or correcting one's reasoning procedure.	36	.72	.45
10. Working from specific facts to general principles.	47	.94	.24
11. Storing, retaining, and recalling information.	25	.50	.51
12. Separating relevant from irrelevant data.	41	.82	.39
13. Moving from a question or a problem toward one correct answer or a solution.	50	1.00	.00
14. Making a prediction of what will happen in the future from given information.	40	.80	.40
15. Summarizing an article in one's own words.	29	.58	.50
16. Analyzing an argument through sketching a graph or drawing a picture.	42	.84	.37

In this section, the participants were required to select the skills that they thought were related to CT. The results presented in Table 2 showed that the mean score of 13 out of 16 items fell in the range of 0.66–1, which indicated that the majority of the participants had accurate CTS knowledge; in particular, all the participants correctly identified item number 13 which is represented by the statement: "Moving from a question or a problem toward one correct answer or a solution." Moreover, the mean scores of two statements (items 11 and 15) were in the range of 0.36–0.65, which suggested that the respondents have an uncertain understanding of CTS. Furthermore, only one item "Delivering information that committed to memory" was in the low range of 0–0.35, as it was correctly answered by only 17 out of 50 participants. This result indicated inaccurate CTS knowledge.

In the second section (Table 3), there were a total of six statements that examine whether the upper secondary school chemistry teachers were familiar with the concept of CT. According to the data, almost all the participants answered four out of six statements correctly, which were in the range of 0.66–1. However, only two items were in the range of 0.36–0.65, which indicated that more than half of the participants were uncertain about the CT concept presented by the statements: "Fair-minded thinking is connected with the accurate assessment of one's own reasoning" and "An important fact that supports the need for an analytic dimension of CT is that the analysis of thinking is presupposed in every subject."

Table 3
Sum, Mean and Standard Deviation (SD) for the Concept of CTS

Statement	**Sum**	**M**	**SD**
1. It is important to clarify thinking whenever you are explaining something to someone; whenever someone is explaining something to you; and whenever you are analyzing an article or chapter.	49	.98	.14
2. Fair-minded thinking is connected with the accurate assessment of one's own reasoning.	32	.64	.49
3. Depth in reasoning best relates to complexities in the issue; logical interpretations; clarifying the issue.	43	.86	.35
4. One main requirement of critical thinking is to analyze thinking into its most basic components.	49	.98	.14
5. Critical thinkers assess thinking in order to determine what thinking to accept and what to reject.	48	.96	.20
6. An important fact that supports the need for an analytic dimension of critical thinking is that the analysis of thinking is presupposed in every subject.	32	.64	.49

The last section for evaluating the knowledge of CT consisted of nine statements which were about the nature of CT (Table 4). In this section, the respondents were required to identify

whether the statements reflected the nature of CT or not. Consequently, it was found that seven out of nine items were correctly answered and within the high range of 0.66–1. Among these statements, only one item with the statement, "Critical thinking enables one to think more deeply" was correctly chosen by 49 out of 50 respondents. The last two items with the statements, "One should not analyze sympathetically the points of view that are disgusting, and obviously false" and "Critical thinkers use subjective standards to assess thinking" were ranged low at 0–0.35, as they were answered correctly by less than half of the respondents. This suggested that the teachers had uncertain knowledge of the nature of CTS.

Table 4

Sum, Mean and Standard Deviation (SD) for the Nature of CTS

Statement	Sum	Mean	SD
1. As people grow older, they naturally develop as critical thinkers.	42	.84	.37
2. Critical thinking is self-disciplined.	39	.78	.42
3. Critical thinking enables one to think more deeply.	49	.98	.14
4. One should not analyze sympathetically points of view that are disgusting and obviously false.	16	.32	.47
5. If a statement is unclear, we benefit by asking what our purpose is in saying it.	35	.70	.46
6. Implications are conclusions you come to in a situation.	40	.80	.40
7. Critical thinking is important in learning to read well.	44	.88	.33
8. Critical thinkers use subjective standards to assess thinking.	17	.34	.48
9. Critical thinkers learn to ignore their emotions when making important decisions.	39	.78	.42

Upper secondary chemistry teachers were surprisingly found to have an accurate knowledge of CTS. There were only a few items related to CTS about which the respondents seemed to have an uncertain understanding. Almost all the items drawn from the questionnaire for investigating the knowledge related CTS in the study were answered correctly by most of the respondents, generating a high mean score (M = .78, SD = .12). This result is in contrast with Alazzi (2008), Gashan (2015), and Stedman and Adams (2012) who found that teachers had unsure knowledge about CT. Similarly, teachers were found to have little familiarity with the meaning and the teaching strategies of CTS (Alazzi, 2008). Gashan (2015) argued that teachers were uncertain as to whether they have the skills necessary to promote CTS among students in the classroom. Educated college teachers might also think that they were appropriately teaching CTS to their students when they were not; moreover, teachers might have insufficient CTS education themselves. The reason behind the lack of knowledge of teachers as mentioned in Stedman and Adams (2012) is the teachers themselves. They might not have had formal education for acquiring CTS; therefore, naturally, if teachers do not understand CT, it is almost impossible for them to teach it to their students.

However, the present study provided results that are noticeably different from those of the previous studies. The rationale behind teachers having accurate knowledge of CTS might originate from their educational level, as most (92%) of the teachers in this study had a bachelor's degree, which they spent four years acquiring, and one year of pedagogical education. Only after attaining these qualifications were they able to become a public school teacher. They experienced both academic and social lives while studying, during which they might have developed their thinking skills.

4.3 The perception of upper secondary school chemistry teachers towards teaching critical thinking skills

The results obtained from the questionnaire analysis indicated the chemistry teachers' perception toward the importance of CTS and the support as well as the difficulties which they encountered while teaching CTS to students. To understand the teachers' perception of CTS, they were asked to determine the level of agreement and disagreement about seventeen statements related to the importance of CTS, the support from relevant stakeholders, and the challenges they faced, as shown in Table 4.5. The results revealed that the mean score of all the seventeen statements was in the high range of 3.5–5, indicating agreement.

The present study found that most of the chemistry teachers strongly agreed on and had a positive perception (M=3.94, SD=.54) toward teaching CTS, which was mainly related to the importance of teaching CTS, the support system built by the relevant stakeholders, and the challenges they face during their teaching practices. These results are consistent with the study by Gashan (2015) which found that pre-service teachers held positive opinions about the value of teaching CT. They strongly agreed that CT engages students in higher-order thinking and encourages them to become independent thinkers and active learners.

In the present study, most of the respondents (88%) agreed that it is their responsibility to promote CT in their course with a high mean score (M = 4.04, SD = .76). This result could be associated with the finding of Stedman and Adams (2012) which found favorable perspectives from the respondents on statements about the need to develop students' CTS. On the other hand, the participants in their study provided a variety of responses that focus on the role of teachers' instruction in promoting CTS.

Furthermore, the findings observed in this study mirror those of Choy and Cheah (2009) who examined teachers' perceptions of CT among students and its influence on their higher education. The study indicated that although teachers believed that they were teaching CT to their students and encouraging CT in the classroom, they were only focusing on explaining the subject matter for the purpose of comprehension. Moreover, they found that the teachers did not understand how to cultivate CTS among students in a classroom environment.

This finding of this study also somewhat corroborates with the idea put forwarded by Stapleton (2011) who suggested that high school teachers had narrow conceptions regarding the concept of CT. They extended strong support for the inclusion of CT in the curriculum and conveyed the desire for the promotion of relevant training on how to develop CT in students along with

Table 5

Sum, Mean and Standard Deviation (SD) for Teachers' Perceptions of CTS

Statement	Sum	Mean	SD
1. Critical thinking engages students' higher order thinking (analyzing, evaluating, and creating).	215	4.30	.84
2. Critical thinking encourages students to become independent thinkers.	193	3.86	1.09
3. Critical thinking encourages students to become active learners.	207	4.14	.90
4. Critical thinking can be used to achieve better learning outcomes.	214	4.28	.76
5. Critical thinking will allow students a better understanding of course topics.	214	4.28	.78
6. Critical thinking is a method of thinking which would help students enjoy the learning process.	195	3.90	.89
7. The Ministry of Education guidelines require me to teach critical thinking.	183	3.66	.85
8. The teacher's manual explains how to teach critical thinking.	181	3.62	.99
9. I used to take a course related to how to teach critical thinking to students during pre-service training.	184	3.68	.87
10. My professors address how to teach critical thinking during the class.	183	3.66	.82
11. I think that students have barriers to critical thinking, regardless of the strategies I use.	204	4.08	.97
12. I find some difficulties (school facilities, parents, material, time…) when I involve student in critical thinking.	199	3.98	.85
13. I have the skills necessary to promote critical thinking by students in my course.	177	3.54	.93
14. I look for specific evidence of critical thinking by students in my course.	181	3.62	.78
15. I believe that it is my responsibility to promote critical thinking in my course.	202	4.04	.76
16. If required, I could implement critical thinking into my course.	203	4.06	.65
17. In order for me to fully implement critical thinking into my course, I would need additional support.	214	4.28	.83

a suggestion to present more precise definitions of CT in educational documents. Regarding their suggestions, to some extent, the participants in the current study showed a strong desire to receive trainings for learning proper CTS teaching methods to fully promote CTS in their classrooms as well as to enhance the subject matter.

Moreover, the qualitative findings of this study also suggested some similarities with those of previous studies regarding the barriers to promoting CTS teaching practice (Almulla, 2018; Alwadai, 2014). The main barriers identified in the present study were insufficient teaching materials, the lack of basic knowledge related CTS among the students, the lack of teacher motivation, difficulties in teacher instruction method for promoting CTS, and too much content in chemistry textbooks. These findings are aligned with Almulla (2018) who found that limited school resources and traditional curricula were key barriers to implementing CTS. The finding from another study by Alwadai (2014) has also reported similar results, outlining seven obstacles to the teaching of CTS such as student ability, classroom structure, teaching methods, pre-service teacher preparation programs and in-service teacher professional and developmental programs, Islamic studies curriculum, the Saudi society, and the school community. However, the finding of the current study differs from that of Aliakbari and Sadeghdaghighi (2013) who found that the major obstacles in practicing critical thinking in the Iranian context were the lack of critical thinking knowledge among teachers, students' attitudes and expectations, and self-efficacy constraints.

Given the discussion on the perception of teaching CTS, the results of this study exhibited strong consistency with those of previous studies, showing positive opinions and strong agreement with the statements used in the questionnaire. Nevertheless, the results generated from the actual practice observed during classroom observations contradicted the results from the reported questionnaire and the interview notes. During their teaching practice, the teachers who were observed seemed to have faced obstacles that were similar to those presented found in previous studies discussed above.

6. Conclusion

The qualitative findings of this study suggest that upper secondary chemistry textbooks provide a minor reference to CTS and include questions only up to the *analyzing* level of the Bloom's taxonomy. Additionally, the quantitative results indicate that chemistry teachers' knowledge is accurate and their perception is positively related to the importance of CTS and the support from policymakers and other relevant stakeholders. However, the teachers have emphasized the existence of some difficulties such as insufficient teaching materials, particularly chemical substances and laboratory instruments, the lack of students' basic knowledge of CTS, the lack of teachers' motivation, limitations in the teachers' instruction methods for CTS implementation, and too much content in textbooks. They also requested policymakers to address these issues. The results indicate that teachers need to fully understand and adequately use CTS in their teaching.

Considering all these results together, there are some possible implications for curriculum developers, policymakers in MoEYS, and teachers themselves. Curriculum developers or textbook designers should re-examine the content of chemistry textbooks and conduct a more detailed analysis of the constraints and potential consequences—positive and negative—by including all the cognitive levels of thinking from Bloom's taxonomy in the chemistry textbooks of upper secondary schools. While incorporating a high level of cognitive skills in

chemistry textbooks may result in some adverse effects, offering more questions that reach three upper levels of thinking to provide learners with CTS as well as comprehensive subject matter knowledge is of utmost importance, not only for the classroom interaction between students and teachers but also for the future work and daily life of students.

Another practical implication that needs to be considered is the promotion of CTS teaching at the school level. The policymakers should provide clear guidelines to foster CTS teaching in the upper secondary education as well as tackle all the barriers that prevent teachers from implementing CTS in their teaching practice. Furthermore, the pre-service and in-service teacher training programs should provide clear instructions on how to cultivate CTS in the teaching practice. Most importantly, the teachers should not depend only on the standard textbooks; they should do more research and gather any available documents that can enrich their knowledge of the subject matter and improve their teaching method to promote the teaching of CTS in the classroom as it is a crucial skill students need to success in their study and life. The current research was not specifically designed to examine the factors affecting teachers' knowledge and perception toward teaching CTS, so future studies could consider assessing the factors that might affect teachers' knowledge about and perception of CTS.

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